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GRAPHITE

PART IV - STATUS OF THE AMERICAN GRAPHITE INDUSTRY

BY

PAUL M. TYLER

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

G R A P H I T E

PART IV. STATUS OF THE AMERICAN GRAPHITE INDUSTRY[1]

By Paul M. Tyler[2]

GENERAL STATEMENT

Graphite is an essential war mineral and for that reason has received much attention from the standpoint of national defense. During the World War the situation with respect to graphite supplies, though it never became acute, caused considerable concern. Even in peace time, however, graphite has aroused more interest than the actual size of the industry seems to warrant. Despite this wide interest the facts of the industry do not seem to be generally known. Often there has been an almost total disregard of the essential economic and technical problems involved. Long ago Bastin[3] made the following statement in a Government report: "To-day there are more abandoned mines and mills in the United States than the number in operation * * *. In the number of times some of these properties have changed hands in the course of a few years, there is a record of misrepresentation and disappointment that can hardly be equaled in any other branch of mining, and many properties have been notoriously associated with stock manipulation of doubtful character."

According to one authority fully 600 graphite mines have failed in the United States, and the record shows that of all these properties scarcely a score have ever succeeded in operating for as much as a year or two. More than 40 mines have been worked at various times in the State of New York alone and at least that many in Alabama. Throughout the country, in fact, there are scarcely a dozen States in which efforts have not been made at some time to exploit graphite deposits. At the present time the list of mines that can be classed as at all active is reduced to less than ten. Failures inevitably occur in all kinds of mining, but the disheartening feature of the record of graphite mining in this country is that so few ventures have even paid back the money put into them and that none has been a conspicuous success.

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1 The Bureau of Mines will welcome reprinting of this article, but requests that the following footnote acknowledgment be made: "Printed by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.)"

2 Assistant to chief, economics branch, U. S. Bureau of Mines.

3 Bastin, E. S., Graphite: Mineral Resources of the United States, U. S. Geol. Survey, pt. 2, 1911.

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Many persons seem to have a mistaken idea as to the actual size of the graphite industry. The total domestic consumption of graphite is so small that, were it merely a matter of tonnage, one moderately large company could easily supply all of it. In the aggregate the United States seldom uses more than 30,000 short tons of graphite annually. The total value of this consumption -- as obtained by adding the proceeds from sales by domestic mines to the foreign market value of imported material plus an allowance to cover the probable value of artificial graphite -- normally is only about one and a half million dollars. Even this rather small consumption is divided up among at least four fundamentally different kinds of natural and artificial graphite and a much larger number of real or fancied varieties. As a result of this condition the maximum potential sales from any one mine in the United States can scarcely amount to more than $200,000 or $300,000 annually. According to the testimony in the recent Tariff Hearings, 87 per cent of the domestic production of flake graphite is furnished by one company.[4] This company, certainly the most successful now operating, has expended more than $2,000,000 in developing its mines and in the construction of milling equipment and the gross value of its annual sales as indicated by the total value of domestic production in recent years has been substantially less than $200,000. Even were the margin between costs and selling prices very much greater than it actually is, the potential returns of new graphite mining ventures would not appear commensurate with the capital investment required.

More significant even than the facts concerning the present small tonnage requirements of specified grades is the question which confronts a prospective new producer as to whether his product can be sold at all. For certain uses and in certain localities it may be possible to market a small quantity of almost any graphitic material provided it is cheap enough, and provided, of course, it contains a fairly high percentage of carbon. But if the price demanded, even for powdered material, is more than 2 cents a pound, the problem of satisfying buyers as to quality becomes of paramount importance.

Under existing circumstances it is not possible for a graphite miner to expand his market except by engaging in the manufacture of finished products. That there is a wide spread between the price of crude graphite and the price of graphite products per pound is well known. A measure of this spread is indicated by a statement in the Tariff Hearings which pointed out the fact that one company whose sales amounted to $1,500,000 annually paid out only $15,000 annually in duties. Since the tariff rate on amorphous graphite under the act of 1922 was 10 per cent on the value of the material f. o. b. mine, it is evident that, even allowing for certain additional materials that enter into the finished articles, the average market value of graphite can be increased about 10-fold by manufacturing it into a varied line of finished products. Before entering these fields, however, the miner must build up a sales organization and conduct an active advertising campaign and otherwise popularize his brands before he can get consumers to take his products. Even the business of manufacturing paint pigment alone requires a great deal of sales effort and additional preparation beyond that connected with the purely mining needs of the business.

4 Brief of the Southwestern Consolidated Graphite Co. Tariff Hearings, Ways and Means Committee, 1929, p. 951.

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PRODUCTION vs. CONSUMPTION

For some years previous to 1914 only about 15 per cent of the apparent consumption of natural graphite in the United States was supplied by domestic mines. In 1914 the proportion was 18 per cent. Even taking the industry as a whole and including both artificial graphite (exclusive of electrodes) and natural graphite, domestic sources contributed only 24.6 per cent of the apparent tonnage consumed in 1914. In 1926 the proportion derived from domestic sources was 50.5 per cent and in 1927, was 42.0 per cent, but this increase is attributable almost wholly to a larger output of artificial graphite. Considering natural graphite alone the proportions for the two recent years were 17.2 and 19.3 per cent, respectively -- only a little greater than the pre-war percentage.

Aside from the increased production of artificial graphite the leading changes in the industry have taken place in the import trade. The quantity and nature of the graphite produced by domestic mines have changed little, but the imports have been reduced substantially in quantity and to a much larger extent in value. As will be seen later the total tonnage of graphite consumed in the United States is about the same now as it was in the years immediately preceding the outbreak of the Great War in Europe. The outstanding difference is that a larger part of this consumption now consists of artificial and amorphous graphite and a much smaller part of it consists of Ceylon lump and expensive grades of flake. On the one hand the decline in the manufacture of crucibles has reduced the demand for the more expensive kinds of graphite, while on the other hand the consumption of the cheaper kinds of graphite has increased.

COMPARABILITY

No problem of the graphite industry is productive of more argument than the question of the relative merits of different kinds of graphite. An unbiased investigator soon finds that the conflicting views of different dealers and users are founded upon honest differences of opinion. In the manufacture of crucibles, for example, various mixtures of clay and graphite are employed and each mixture has to be handled differently. Experiende has shown that one kind of clay can not be substituted for another without changing other factors in the process, and that the same is true of different kinds of graphite. Since it takes at least a year to work out the manufacturing technique to test the merits of a new mixture in actual melting service, it is not surprising that manufacturers are reluctant to depart from established practices.

The graphite industry, it should be remembered, is in many respects a complicated one. Attempts to state its problems as broad generalities tend to obscure the facts that there are three or four wholly different types of graphite with several grades of each type. Moreover graphites of nominally the same grade may not be interchangeable because of differences in purity and physical condition. Despite occasional attempts at standardization, the specifications for many grades are not well established, and even when established they are not always adhered to. A great deal depends upon the process of beneficiation and the care given to

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maintaining quality or at least an even grade. Since one type of graphite can to a limited extent be substituted for another, the matter of careful grading is of extreme importance. The foundry-facing trade, for example, uses crystalline dust, low-grade flake, and amorphous or artificial graphite more or less interchangeabl; at the same time all of these graphites compete not only with one another but wit amorphous carbon and with mineral facings such as mica or silica. Since foundry facings, despite their wide variety, are not merely hit or miss mixtures, the miner or dealer who can furnish a dependable guarantee of quality has a great advantage in competition with a sporadic producer whose occasional shipments almost of necessity will be uneven in grade. In a statement presented to the Ways and Means Committee in February, 1919, 14 manufacturing jobbers engaged in the plumbago foundry facing business maintained that the Alabama dust carries grit, is harder to grind than the imported, and is not naturally as well fitted for foundry facings as the Ceylon graphite. Both Alabama and Pennsylvania graphite dust were said to be of inferior refractory quality because of their large silica and mica content which fuses under the pouring heat of the molten metal and prevents a smooth surface. These troubles are to some extent a matter of inadequate preparation for market. The same difficulty has contributed to the attitude of crucible manufacturers, many of whom objected to using domestic flake even as an admixture with Ceylon plumbago. The relatively rapid adoption of artificial graphite as compared with the consumption of competing types of natural graphite has to an important extent been due to the fact that the quality is under control and can be depended upon.

The successful introduction of the oil flotation process for cleaning graphite ores should result in better uniformity of domestic natural graphite, particularly of the flake variety, and may result in their displacing certain kinds of imported graphite. If at the same time domestic flake can be produced more cheaply it may react adversely upon the sales of domestic amorphous. In considering consumption trends and competitive conditions, therefore, it is necessary to keep clearly in mind that a number of different products differing widely in properties and price are all classed together as graphite.

That there is a great difference between Ceylon lump selling for almost 10 cents per pound and Rhode Island amorphous selling for under three-fourths of a cent is self-evident, but it is not so plain that domestic crystalline flake may range in price from $2\frac{1}{2}$ to 10 cents per pound as was the case in 1925, according to reports of producers to the Bureau of Mines. Part of this difference was explained, of course, by the fact that these prices were at the mines and hence did not include transportation to consuming markets; but one of the main causes for th wide range in value was the greatly different degree to which the products were prepared for market. This situation is reflected by the divergent reports of market conditions that are received from different dealers but more particularly from domestic miners. Even in the same district one operator finds business good while at the same time another fails to move his product. Among the imports there are similar differences, although the tendency is now for graphite to be more highly refined before being sent to this country. Ceylon graphite has always been carefully prepared, but much Madagascar and Canadian flake, for example, formerly had to be cleaned in this country before it was fit to be used. Under these circumstances an unknown percentage of the total tonnage reported in the statistics as graphite actually represented impurities,

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and consequently the yield of usable graphite was substantially less than is indicated by the statistics.

TOTAL CONSUMPTION

Considering the graphite industry as a whole the situation is illustrated in the following table:

Consumption of Graphite in the United States, 1914 - 1927

Year	Domestic sales a/	Add imports	Available for consumption	Less exports	Apparent consumption	Percentage domestic
1914	6,660	21,990	28,650	1,960	26,690	25.0
1915	7,260	23,075	30,335	524	29,811	24.4
1916	12,287	42,930	55,217	798	54,419	22.6
1917	18,830	42,577	61,407	2,573	58,834	32.0
1918	17,582	19,498	37,080	954	36,126	48.7
1919	11,504	26,626	38,130	629	37,501	30.7
1920	13,210	21,096	34,306	607	33,699	39.2
1921	5,381	8,183	13,564	921	12,643	42.6
1922	9,641	12,488	22,129	569	21,560	44.7
1923	19,419	19,434	38,853	908	37,945	51.2
1924	10,464	16,375	26,839	1,022	25,817	40.5
1925	10,733	17,768	28,501	945	27,556	38.9
1926	16,052	16,116	32,168	405	31,763	50.5
1927	11,326	17,452	28,778	1,819	26,959	42.0

a/ Including both artificial (except electrodes) and natural graphite.

The foregoing table brings out in a general way the dependence of the United States on foreign sources of supply. To a certain extent also it shows that this dependence is less serious now than formerly, although these altered circumstances would be more apparent if it were possible to show figures for pre-war years. Unfortunately, however, the production figures for artificial graphite prior to 1915 related both to electrodes and to powdered or bulk graphite, whereas more recently such figures relate only to powdered graphite. It would seem, however, that the output of artificial powdered graphite for most years prior to 1914 was relatively small; as the imports in 1912 and 1913 were much larger than they were in 1914, it follows that previous to the outbreak of the war in Europe the proportion of graphite supplies derived from domestic sources amounted to substantially less than one-seventh of the consumption.

As has been previously noted, the leading causes of this increased independence of foreign supplies are (1) a decreased demand for crucible graphite and (2) an increased output of artificial graphite. Although imports of crystalline and amorphous graphite have been recorded separately in the trade statistics only since the Tariff Act of 1922, it is possible to estimate fairly closely the imports for previous years by noting the country of origin. Ceylon graphite, of course, is crystalline, as are also imports from Madagascar and Canada. Since a little Madagascar and Ceylon material has been imported by way

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of Great Britain or France, imports from these and from a few other secondary sources have been classified as crystalline, while imports from Japan, Chosen, Mexico, Italy, Austra, and so on, are considered to be amorphous.

CONSUMPTION OF CRYSTALLINE GRAPHITE

The following table, with figures estimated as indicated, shows a diminution in the consumption of crystalline graphite from the 20,000 short tons immediately before the war to approximately 10,000 tons after the war. The drastic curtailment both in domestic sales and imports in 1921 and 1922, following the relative large imports of previous years, indicates the absorption of surplus stocks.

Consumption and sources of supply of crystalline graphite in the United States, in short tons, 1912 - 1927

Year	Domestic sales	Imports a/	Apparent consumption	Percentage domestic
1912	1,772	19,508	21,280	8.3
1913	2,532	19,288	21,820	11.6
1914	2,610	11,083	13,693	19.1
1915	3,537	18,995	22,532	15.7
1916	5,466	32,160	37,626	14.5
1917	5,292	32,462	37,754	14.0
1918	6,431	13,313	19,744	32.6
1919	4,043	20,972	25,015	16.2
1920	4,816	16,115	20,931	23.0
1921	595	4,085	4,680	12.7
1922	925	8,445	9,370	9.9
1923	1,982	8,182	10,164	19.5
1924	900	5,439	6,339	14.2
1925	1,129	8,558	9,687	11.7
1926	2,495	7,866	10,361	24.1
1927	2,612	7,893	10,505	24.9

a/ Imports for consumption; figures for crystalline graphite reported separately by Bureau of Foreign and Domestic Commerce only since 1922. Data for former years estimated on basis of countries of origin.

CONSUMPTION OF AMORPHOUS AND ARTIFICIAL GRAPHITE

The consumption of amorphous graphite and of powdered artificial graphite may be considered together, as the two materials compete quite freely with one another in many different uses. It should be noted, however, that recently a large percentage of the output of artificial graphite has been used in the manufacture of dry cells, competing in this application with flake rather than with amorphous. Because of the altered policy of the Acheson Graphite Co. in reporting

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its statistics before and after 1915, it is impossible to give figures which will show the full extent of the expansion in the use of these two qualities of graphite. Moreover, while it is known that a large part of the exports of "unmanufactured graphite" as reported by the Bureau of Foreign and Domestic Commerce consists of amorphous or artificial graphite, minor amounts of crystalline graphite have been exported, particularly during the war years, but since there is no means of estimating the quantity of crystalline graphite so included, all of the exports are herein considered as being either amorphous or artificial graphite.

In general it may be said that the reduction of 10,000 tons in the consumption of crystalline graphite has been balanced as regards quantity by an increase of approximately the same amount in the consumption of amorphous and artificial graphite. Much of this increase is attributable to the great expansion in production of artificial graphite, although imports, most of which come from American-owned mines in Mexico, have also increased. Domestic-mine production of amorphous graphite prospered more or less during the war, but it subsequently appears to have suffered from the competition both of artificial graphite and of the dust and second-grade flake produced more or less as a by-product of mines that produce crystalline flake. Various kinds of amorphous carbon, notably anthracite coal, and other substitutes have also been factors affecting the consumption of natural graphite.

Consumption and sources of supply of amorphous and artificial graphite in the United States, in short tons, 1912-1927

Year	Domestic Production		Total	Add Imports	Apparent supply	Less exports (c)	Apparent consumption	Percentage domestic
	Natural amorphous (a)	Artificial (b)						
1912	2,063	(d)	(d)	6,033	(d)	2,320	(d)	(d)
1913	2,243	(d)	(d)	9,501	(d)	2,692	(d)	(d)
1914	1,725	(d)	(d)	10,907	(d)	1,960	(d)	(d)
1915	1,181	2,542	3,723	4,080	7,803	529	7,274	51.2
1916	2,622	4,199	6,821	10,770	17,591	798	16,793	40.6
1917	8,301	5,237	13,538	10,115	23,653	2,573	21,080	64.2
1918	6,560	4,591	11,151	6,185	17,336	954	16,382	68.1
1919	3,379	4,082	7,461	5,654	13,115	629	12,486	59.8
1920	4,694	3,700	8,394	4,981	13,375	607	12,768	65.7
1921	1,842	2,944	4,786	4,098	8,884	921	7,963	60.1
1922	2,200	6,516	8,716	4,043	12,759	569	12,190	71.5
1923	4,056	13,381	17,437	11,252	28,689	908	27,781	62.8
1924	4,071	5,493	9,564	10,936	20,500	1,022	19,478	49.1
1925	3,536	6,068	9,604	9,210	18,814	945	17,869	53.7
1926	2,975	10,582	13,557	8,250	21,807	405	21,402	63.3
1927	2,595	6,129	8,724	9,559	18,283	400 (e)	17,883	48.8

(a) Sales.
(b) Powdered graphite (exclusive of electrodes).
(c) Probably includes some crystalline flake in some years.
(d) Data not available previous to 1915. Artificial graphite was included with electrodes in published statistics.
(e) Estimated. Under new classification exports of "graphite and manufactures except crucibles," in 1927 were 1,819 short tons valued at $435,997. Since exports of manufactures of graphite alone had a value of $463,084 in 1926, it is assumed that exports of unmanufactured graphite were probably no larger than in the previous year.

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COMPETITIVE CONDITIONS

The competitive ability of the domestic graphite industry depends to an important degree upon the quality of its products. Established reputation and buying habits induced by the long dependence of consumers upon foreign sources of supply afford definite problems to be met by an expanding domestic industry, but certainly outside of the crucible field, they do not constitute insurmountable handicaps to a domestic producer who can guarantee regular delivery and good uniform quality.

Competition in the domestic graphite market is becoming more and more a matter of price. This is certainly true with respect to competition between products of the same variety and purity; and in the case of many consuming outlets, it is true also that products of different grades compete with one another largely on a price basis. This latter statement, of course, does not mean always that they are interchangeable pound for pound at the same price, but it does mean that consumers as a rule are inclined to buy any of several varieties of graphite which may be offered to them and pay according to the relative service rendered. Formerly they were less ready to do this, preferring always to buy Ceylon graphite or some other variety with a well-established reputation. Sometimes consumers are willing to buy an impure product and refine it themselves, but the tendency is to place the burden of preparing graphite for final consumption upon the producer, where it rightfully belongs. Moreover, the employment of perfected process of oil flotation makes it easier now to produce a finished product at the mines.

Previous to the World War, Ceylon lump and even chip commanded a considerably higher price per pound than flake graphite, but in later years the differential has been greatly reduced. Throughout the world Madagascar flake has displaced Ceylon grades to a greater or less extent even in the manufacture of crucibles, and in consequence Ceylon producers have been forced to reduce their prices. In 1913, first-grade Ceylon chip was quoted in New York at 7½ to 10 cents per pound, whereas Madagascar, Canadian, or domestic flake could be bought for 5 or 6 cents per pound, indicating an average premium of at least 3 cents per pound in favor of this medium size of vein graphite. In 1928, on the other hand, Ceylon chip and the various grades of high-grade flake were all quoted in New York nominally at the same price, 6½ to 7½ cents per pound. Actually domestic and Madagascar flake were still somewhat cheaper, but the difference was very slight as compared with former times. The premium on Ceylon plumbago which, because of the enlarged demand for crucibles increased greatly during the war, has subsequently tended to disappear. Even for Ceylon graphite the differentials between the different grades have been much reduced as may be seen from the following table:

Quotations of Ceylon graphite per pound in New York for selected years

	1913	1917	1928
Lump (1st grade)	9½-11	28-32	7½-9½
Chip (1st grade)	7½-10	20-23	6½-7½
Dust (1st grade)	4 - 5½	11-13	3½-5½

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Almost regardless of price, Ceylon lump and chip will continue to be used as raw material for crucible making. The only known domestic mine which has produced material physically similar to Ceylon graphite is situated at Dillon, Mont. Except at war-time prices, the Crystal Graphite Co. which operates this mine has never yet demonstrated an ability to compete in eastern markets with Ceylon producers. Development has continued and the mine has been opened up so that it can be worked to better advantage; a small mill has been built to prepare the products for market, but the sales in recent years have been confined to western consumers and future plans appear to be based largely upon the western market which is not large. These facts indicate that vein graphite can not now be produced in Montana and delivered in eastern consuming centers at the prices of comparable Ceylon grades. Transportation is one factor; it costs more to haul the Montana product to the Atlantic Seaboard by rail than it does to ship the imported material halfway around the world by water. Differences in wages tend further to handicap the American producer, who must meet the western mining camp scale of wages although the deposit does not afford much opportunity for compensating economies that will reduce unit cost by use of large-scale methods.

With the decline in the demand for crucible grades of graphite, the market for flake has improved -- at least relatively. Madagascar has established itself in many markets, displacing Ceylon plumbago both in the United States and abroad. Madagascar flake, since it has not the established reputation which is still accorded to the better grades from Ceylon, must sell on an equal footing with comparable domestic flake. It has been stated that Madagascar flake is a little thicker than that produced in Alabama and the new guarantees as to uniformity provided by the Government seal have been used as sales arguments, but although imported and domestic flake may not be interchangeable, they do sell at very nearly the same price. Under these circumstances the relative cost of the finished product delivered in the principal consuming centers of the United States is the determining factor in competition. Despite the relatively high value of the product, transportation is an important item, and for this reason Madagascar flake is consumed mainly along the seaboard. Canadian graphite is most strongly entrenched in the neighborhood of the Great Lakes. Alabama graphite mines, on the other hand, are not well situated with respect to consuming markets. The freight rate to New York is $16.10 per short ton, whereas the rate from Madagascar, including transhipment at Havre, is $16 (it has been as low as $8.67), and the rate from Ceylon to Atlantic seaboard points of the United States ranged in recent years from $5.50 (1928) to $8.75 (1925). To Pittsburgh the rate from Alabama points is $16.50, while from Canadian mines it is only $9.50. The Texas mines likewise are far from the main consuming centers, hence their product formerly had to be sold to a large extent locally, mostly in the southern part of the Mississippi Valley. California production (used mainly for foundry facings) also has to be sold in nearby territory. Only one mine in the United States, that at Annandale, N. J., 55 miles from New York, is situated near the great eastern markets, and in 1928 this property had not started to produce on a commercial scale.

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The freight rates (1928) from the leading domestic mines to certain consuming districts are given in the following table:

Freight rates (carloads) from domestic mines per short ton in 1928

Destination	From Alabama (Hollins)	From Texas
New York	$16.10	$ 9.72 (a)
Chicago	16.30	10.35
Madison	- -	10.35
Bethlehem, Pa.	16.10	- -
Philadelphia	14.90	- -
Pittsburgh	16.50	12.95
Baltimore	13.30	- -
Ohio points	10.70	11.65 to 12.00

(a) By water.

In addition to the transportation handicap resulting from the fact that the main consuming centers are closer to the Atlantic seaboard or the Canadian boundary than they are to many of the leading domestic producing centers, domestic deposits are of lower grade than many of those found abroad. Regardless of labor conditions and relative wages the domestic deposits are more costly to work because the yield of flake per ton of rock mined is almost invariably less and generally very much less than it is abroad. In Madagascar there are deposits that yield 30 and even 50 per cent. In Alabama the yield amounts to scarcely 2½ per cent; in Texas and Pennsylvania it is only 3 to 4 per cent, whereas in Canada the rock at the Black Donald mine contains an average of 65 per cent, and elsewhere in Canada graphite mines have been opened in rock containing 25 per cent graphitic carbon. The Canadian graphite industry, therefore, seems to be in a peculiarly advantageous position. The deposits are extensive and not far distant from the large markets of the United States, power is cheap, and cost of production is so low that Canadian flake should be laid down in New York, Pittsburgh, London, Liverpool, Hamburg, or Bremen, cheaper than that produced anywhere else in the world. In the past the Canadian industry, in common with that of the United States, has been held back by inefficient methods of beneficiation. The adoption of oil flotation, however, promises to do away largely with this difficulty. At the Black Donald property coarse flake containing 88 to 99 per cent graphite has been regularly produced; the No. 2 (medium) flake contained 92.5 per cent graphite while the No. 3 (fine) contained 95.5 per cent graphitic carbon. About 20 per cent of the total product is used for ground stocks. The graphitic carbon content of which ranges from 74 to 92 per cent. Some portion of the Canadian graphite which is finely crystalline is commercially known as "amorphous" and is imported under that designation.

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A factor which tends to strengthen the competitive status of both domestic and Canadian graphite mining is the increase in the demand for dust and the smaller sizes of flake which has resulted from the rapidly growing consumption of graphite for foundry facings, paints, dry batteries, and lubricants. Formerly, when the demand was principally for No. 1 flake suitable for making crucibles, these joint products often had to be thrown away. According to the leading domestic producer, however, it is "absolutely impossible for any plant to survive on the sale of low-grade products alone."[5]

Some of the amorphous graphite produced in the United States is low in carbon, and none of it sells for high prices. Graphite of this sort is mined chiefly in Rhode Island, Nevada, and Michigan, and its principal recommendation is that it is cheaper than any suitable material obtainable from abroad. Some of it is worth only $5 to $10 per ton at the mines. As even the New York price of crude amorphous graphite is usually under $20, it is clear that domestic mines situated near consuming centers have a tremendous advantage with respect to supplies that have to be imported from any considerable distance. Since much of the amorphous graphites must be pulverized before entering into final consumption, the principal competition encountered by domestic producers of this kind of material comes from the low-grade dust produced in the refining of crystalline flake. For many purposes, on the other hand (notably for the manufacture of pencils and for lubricants and to a lesser extent for foundry facings), quality is of great importance even for amorphous graphite. This feature has been emphasized by operators of high-grade graphite mines in Sonora, with the result that Mexico now furnishes a larger and larger percentage of the imports of amorphous graphite, and products made therefrom -- especially pencil graphites -- are exported in substantial quantity. During the first half of 1928 almost 4,000 tons of graphite were imported from Mexico -- a considerable increase as compared with 6,283 tons imported from the same source in 1927. The total domestic production of amorphous graphite, most of it consisting of extremely low-grade material, is much smaller, amounting in 1927 to only 2,595 short tons. The United States has an abundance of amorphous graphite, deposits being found in many States and in various parts of the country. Both Mexico and Chosen, however, have larger and better deposits and, despite their greater distance from American markets, have captured much of the business where quality counts.

Under the Tariff Act of 1922 a duty of 10 per cent ad valorem was placed on amorphous graphite, but nevertheless imports are substantially larger and domestic production is smaller than formerly when all graphite was on the free list. Even as compared with pre-war production the domestic output has increased only slightly. The use of artificial graphite, on the other hand, has expanded greatly, as it is cheaper than natural graphite of equal purity. Moreover, the larger supply of low-grade crystalline graphite obtainable at competitive prices has further contributed to discourage the working of amorphous graphite mines in the United States.

The freight rate from Sonora to Saginaw, Mich., where the bulk of the Mexican material is prepared for market, is $12.50 a short ton, and, based on the average declared value of $8.57 in 1927, the 10 per cent duty adds $0.86 per short ton. The ocean freight rate from Japan or Chosen to the Atlantic seaboard has averaged in recent years about $8.95 per short ton.

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[5] Burrage, Robert, Brief presented in Tariff Hearings: Ways and Means Committee, January, 1929, p. 952.

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COSTS OF PRODUCTION

For the period 1918 to 1919, domestic operating costs, as ascertained by the Bureau of Mines, ranged from 6 to 14 cents per pound, averaging about 10 cents per pound of No. 1 flake.[6] In ascertaining these costs the No. 1 flake was charged with the entire operating expense and then credited with the income received from the sale of No. 2 flake and dust, which were considered as by-products. No allowance was made for depletion and depreciation. Such allowances would add perhaps 1 or 2 cents per pound. These costs, of course, represent the peak of war-time conditions and are not representative of the industry in later years. Although most of the Alabama plants have been closed, the following figures, said to represent the cost and market prices of crucible grades only, are of interest as indicating the advances that took place during the progress of the Great War.[7]

Year	Cost per pound, cents	Market price per pound, cents
1914	4	6-7
1915	5	7-8
1916	6	10-13
1917	8	10-20
1918	10	11-20

At the Tariff Hearings in 1919 and again in 1921 considerable evidence was submitted to show that the costs of production of domestic graphite were substantially higher than they were in foreign producing countries. As shown by cost statements submitted in confidence to the Bureau of Mines, this condition has been modified somewhat by improved methods of beneficiation and more economical mining, but it may be noted that on Texas graphite the freight and grinding costs alone amount to 1½ cents per pound of product, and on Alabama shipments the freight equals 0.5 cent; these costs must be considered in view of the close margins on treating ore yielding less than 25 pounds of product per ton of rock milled.

The best available evidence as to foreign costs can be obtained from a study of the invoice values of graphite imported from the leading producing countries. These figures include profit and certain handling charges in the countries of origin but do not include ocean freight or handling charges and commissions in the United States. During the calendar year 1927 the declared value of flake graphite imported direct from Madagascar was 3.84 cents per pound, whereas the imports from Madagascar graphite by way of France were valued at 5.23 cents per pound as compared with 6.74 cents per pound from Canada. The average of all kinds of imported crystalline flake is 5.25 cents per pound.

6 Dub, George D., Preparation of Crucible Graphite: War Minerals Investigation, Series, No. 3, Bureau of Mines, 1918, p. 22.

7 Testimony of A. B. Conklin, Secretary of the Graphite Producers' Association of Alabama, before Ways and Means Committee, Sept. 26-7, 1919.

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As estimated by the Compagnie Générale de Madagascar in January, 1927, the cost of Madagascar graphite, 85 per cent grade, f.o.b. Tamatave, was 1,450 francs for the Antsirabe region, 1,750 francs for the Anivorano region, and 975 francs for the Vatomandry region. However, the British-owned Maskar Co. which dominates the local market, estimated the costs for the Antsirabe district at only 1,600 francs as compared with 1,900 francs per metric ton which it was paying for 85 per cent material laid down at Tamatave warehouse.[8] With the fr[redacted] stabilized at 3.9 cents, a price of 1,900 francs per metric ton is equivale[redacted] 3.38 cents per pound as compared with the price of 3.84 cents indicated by [redacted] American import statistics as the average f. o. b. value, a difference of a trifle more than one-fourth of a cent per pound.

LIST OF GRAPHITE MINES AND PRODUCERS

Alabama:
- Chilton County:
  - Mountain Creek:
    - Bama Graphite Mines (Montgomery, Ala.)
- Clay County:
  - Ashland:
    - Alabama-Quenelda Graphite Corp. (Birmingham, Ala.)
    - National Flake Graphite Co. (Ashland, Ala.)
    - Superior Flake Graphite Co. (Chicago, Ill.)
- Coosa County:
  - Hollins:
    - Southwestern Consol. Graphite Co. (Boston, Mass. -- also operates in Texas.)
  - Sylacauga:
    - Diamond Graphite Co. (Alexander City, Ala.)

California:
- Los Angeles County:
  - La Crescenta:
    - Standard Graphite Corp. (Los Angeles, Calif.)
  - San Fernando:
    - The Los Angeles Graphite Co. (Los Angeles, Calif.)
  - Sagus:
    - California Graphite Co. (Los Angeles, Calif.)

Colorado:
- Gunnison County:
  - Quartz:
    - Graphite Corp. (Cleveland, Ohio.)

Idaho:
- Blaine County:
  - Ketchum:
    - Griffith & Hampton (Ketchum, Idaho.)

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8 Mining Journal (London), "Graphite production of Madagascar in 1926": May 28, 1927, p. 465.

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Michigan:
Baraga County:
L'Anse:
Detroit Graphite Co. (Detroit, Mich.)

Montana:
[redacted]eaverhead County:
Dell:
National Carbon Co., Lessee (New York City.)
Dillon:
Crystal Graphite Co.

Nevada:
Ormsby County:
Carson:
Carson Black Co. (Oakland, Calif.)

New Jersey:
Hunterdon County:
Annandale:
Annandale Graphite Corp. (Philadelphia, Pa.)

New York:
Niagara County:
Niagara Falls and Buffalo: (Artificial graphite)
Acheson Graphite Co. (Niagara Falls, N. Y.)
Warren County:
Graphite and Ticonderoga:
Joseph Dixon Crucible Co. (Jersey City, N. J.)
(American Graphite Co.)

Oklahoma:
Atoka County:
Atoka:
H. Y. McBride (Denver, Colo.)

Pennsylvania:
Chester County:
Byers and Chester Springs:
T. D. Just Co. (Chester Springs, Pa.)
Chester Springs:
Harry A. Schmehl (Chester Springs, Pa.)
(Not a producer - recovers graphite from old crucibles.)

Rhode Island:
Providence County:
Cranston:
Graphite Mines Co. (Providence, R. I.)

Texas:
Burnet County:
Burnet: (Also in Ala.)
Southwestern Consolidated Graphite Co. (Boston, Mass.)

Virginia:
Roanoke County:
T. O. McAdoo (Salem, Va.)

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